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Lab. Project 5046-3, Part 62
Final Report
NS 081-001

AW-7

MATERIAL LABORATORY

NEW YORK NAVAL SHIPYARD
BROOKLYN 1, N. Y.

TECHNICAL REPORT

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RESEARCH AND DEVELOPMENT REPORT
on
CRITICAL THERMAL ENERGIES
of
CURTAIN MATERIALS
Submitted by
THE WRIGHT AIR DEVELOPMENT CENTER
Department of the Air Force
Lab. Project 5046-3, Part 62

Final Report NS 081-001

27 August 1954
Technical Objective AW-7
AFSWP-400

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Lab. Project 5046-3, Part 62
Final Report

ABSTRACT

For the purpose of evaluating the resistance of materials to the thermal radiation of atomic explosions, the critical thermal energies of several curtain materials, selected, prepared and submitted by the Wright Air Development Center, were determined. Several parameters of importance to the immediate problem were studied, including changes in irradiance, the effect of soiling and the fabric before exposure, the effect of cleaning following soiling, and the effect of previous exposure to approximately 75 per cent of the exposures required to obtain initial radiation effects, and the influence of the degree of bleaching of the fabrics. It was found that the critical thermal energies were greater for exposures at a rate of application of energy of 20 cal/cm^{2}sec than at a rate of application of 85 cal/cm^{2}sec. In general, soiling caused a decrease in resistance to thermal radiation, although the silicone rubber on glass cloth showed the opposite trend. The effects of pre-exposure were only moderate. The 10 per cent bleaching process was most effective in increasing resistance to thermal radiation and the greatest resistance was found on the 14.7 oz. cotton duck with this bleaching.

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ADMINISTRATIVE INFORMATION

1. This investigation was requested by Wright Air Development Center letter WCRTT-1 of 1 March 1954 and constitutes part of the program initially proposed by Commander, New York Naval Shipyard, Confidential letter S99/L5, Ser 960-92 of 14 March 1950 and formally approved by Bureau of Ships speedletter S99(0)(348), Ser 348-75, of 6 April 1950. The general Thermal Radiation program at the Naval Material Laboratory is under the supervision of the Armed Forces Special Weapons Project.

2. The studies reported herein were planned and executed under the supervision of T.I. Monahan, Head of the Optics Section.

INTRODUCTION

3. As part of its general program on the effects of the thermal radiation of atomic explosions, the Naval Material Laboratory is evaluating the characteristics, under exposure to intense thermal radiation, of the various materials of particular interest to the several agencies of the Department of Defense. As data become available, these findings are published. Reported below are the critical thermal energies of curtain materials which were submitted by the Wright Air Development Center. These curtains are intended to be drawn across cockpit windows in order to shield aircraft personnel against the intense thermal radiation attending nuclear detonations.

EQUIPMENT AND METHODS

4. The critical thermal energies of the fabrics were determined, employing the Naval Material Laboratory carbon-arc source of thermal radiation. The source consists of an 11-mm carbon arc, mounted at the focus of a reflector which collimates the emitted energy. A second mirror, which is mounted coaxially at a distance of twelve feet from the collimator, condenses the radiation to the mirror's focus. Gradations of thermal damage are obtained by varying the effective exposure time by accelerating a 1x8 inch specimen transversely through the focus. The carbon arc furnishes an irradiance of 85 cal/cm^{2}sec. over a central area 2 mm in width. In the first phase of the investigation, designated as "Test Code A" by WADC, the five fabrics were also exposed at 20 and 42 cal/cm^{2}sec, which were achieved through the use of attenuating screens. In the second and third phases of the research, "Test Codes B and C", four fabrics were exposed, after having been soiled artifically and after having been soiled and then cleaned. The soiling and cleaning experiments

were conducted at Wright Air Development Center. In the fourth phase, "Test Code D", four fabrics were exposed after having been irradiated by a total energy approximately 75 per cent of that required for initial destruction effects. In the last phase, "Test Code E," one of the fabrics, the 14.7 oz cotton duck, was evaluated with six separate stages of bleaching(0,25,50,75,100,125 per cent) and at a rate of application of energy of 20, 42, and 85 cal/cm^{2}sec.

RESULTS

INFLUENCE OF IRRADIANCE

5. The data of Table 1 indicate that for a rate of application of energy (irradiance) of 20 cal/cm^{2}sec, greater exposures are required in general to cause destructive effects on the materials than for a rate of delivery of energy of 85 cal/cm^{2}sec. It may be concluded that a given curtain material, with the exception of the vinyl-coated cotton, aluminized, will give adequate protection against high-yield nuclear weapons if it gives satisfactory protection against low-yield weapons, such as the "nominal" bomb.

6. During the exposures it was noted that the initial destructive effects are not similar for all irradiances. After charring, all the fabrics ignite, and with the exception of the cotton duck, flameproofed with Pyroset, support combustion after irradiation. The glass cloth emits dense smoke and large sooty particles during exposure. This material and the asbestos cloths are the most resistant to the initial effects of radiation.

EFFECTS OF SOILING

7. The experimental data on the effects of soiling are only qualitative, since it is impossible to control the degree of soiling, the amount and thickness of the soiling materials. In addition, it is impossible to obtain a homogeneous coating, even over the area of an individual specimen. Initial destructive effects under irradiation were not readily discernible because of the soiling.

8. In 3 of the 4 cases, the critical thermal energies were lowered significantly by the soiling. The resistance of the fourth material, the silicone-rubber-on-glass cloth, was increased, but it was noted that the soil coating applied to these samples was heavier than that applied to the other specimens. That soiling may increase in some cases and in others decrease the thermal resistance of a material is not contradictory since the size of soil particles is critical and the effective color and absorptance of the material may be either increased or decreased.

EFFECTS OF SOILING AND CLEANING

9. The initial destructive effects on the materials, first soiled and then cleaned prior to irradiation, with the exception of the vinyl-coated cotton, occurred at radiant exposures considerably lower than those for the corresponding new cloths. The destruction under irradiation of the asbeston and cotton duck materials, soiled and cleaned, occurred at lower radiant exposures than for the corresponding new cloths, but at higher radiant exposures in the case of the silicone-rubber-on-glass-cloth specimens.

EFFECTS OF PREVIOUS EXPOSURE TO RADIATION

10. Twenty-four hours prior to the final exposures, the fabric specimens were conditioned at the Naval Material Laboratory by exposing them to the carbon-arc source of radiation at an irradiance of 85 cal/cm^{2}sec. It has been recommended that the materials be exposed to a total flux approximately 75 per cent of the flux required to cause initial destructive effects on new materials. Because this procedure would involve complex and time-consuming instrumentation, the initial exposures were made at total flux values which could be obtained conveniently. The radiant exposures for the initial exposures and the critical radiant exposure values for the final exposures are given in Table 1.

11. The critical thermal energy for initial destructive effects on Asbeston previously irradiated by 8.0 cal/cm^2, is 8.8 cal/cm^2, in contrast with the critical radiant exposure of 18 cal/cm^2 for new Asbeston cloth. Following an initial radiant exposure of 10.0 cal/cm^2, it required 18 cal/cm^2 to char the Asbeston, the same total energy required to char new Asbeston.

12. The silicone-rubber-on-glass cloth required 18 cal/cm^2 to produce initial destructive effects, even after a previous exposure of 9.0 cal/cm^2. The first exposures of the vinyl-coated cotton and the bleached cotton duck had negligible effect on the critical thermal energies of these materials.

EFFECT OF DIFFERENT DEGREES OF BLEACHING

13. The unbleached fabric was considerably less resistant than any of the bleached specimens. The several degrees of bleaching gave substantially the same amount of protection.

CONCLUSION

14. The results of this investigation are briefly summarized as follows:

a. The critical energy required to produce a specific damage on a curtain material increases if the irradiance decreases from 85 to 20 cal/cm^{2}sec.

b. In general, soiling of curtain materials will cause a decrease of their resistance to thermal radiation. This is also true, although to a smaller extent, after cleaning of these materials. However, the silicone rubber fabric on glass cloth showed the opposite trend and emitted dense smoke and sooty paricles during exposure.

c. Of the investigated fabrics the greatest resistance to thermal radiation was shown by the untreated, 14.7 oz., bleached cotton duck.

d. In most cases, the effects of pre-exposure were only moderate.

Approved:

A.B. JONES, JR., CAPTAIN, USN
The Director

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Table I

Critical Thermal Energies of Curtain Materials

Test Code	WADC Mat'l Designation	Material	Description of Effect	Critical Energies (cal/cm^2)		
				At H= 85 cal/cm^2/sec	At H= 42.5 cal/cm^2/sec	At H= 20 cal/cm^2/sec
A	I	Asbestos, MIL-C-8240 Type I	Initial Effect	18.0	--	--
			Charring	19.0	42.0	60.0
			Burned through, destroyed	43.0	66.0	80.0
A	II	Silicone Rubber on Glass Cloth No. 126 (Chemical Rubber Co. Style 7007)	Initial Effect	21.0	22.0	31.0
			Rubber coating destroyed	49.0	69.0	75.0
A	III	Vinyl Coated Cotton, Aluminized, MIL-C-7642, Type I	Initial Effect	3.0	3.6	4.7
			Charring	31.0	23.0	30.0
			Burned through, destroyed	42.0	42.0	41.0
A	IV	Bleached Cotton Duck, Preshrunk, CCC-D-771, Type III, 14.7oz. Pyreset TO Treatment	Initial Effect	--	--	41.0
			Sporadic Charring	6.8	13.0	56.0
			Regular Charring	21.0	44.0	80.0
			Charred through, destroyed	42.0	44.0	80.0
A	a	XPO White Vinyl on 1.32oz. sateen (Landers Corp.)	Initial Effect	7.4	9.0	18.0
			Sporadic Charring	7.5	17.0	37.0
			Regular Charring	20.0	32.0	64.0
			Charred through, destroyed	46.0	48.0	80.0
A	b	White Vinyl Coated on Nylon Fiberthin (Landers Corp.)	Initial Effect	7.0	9.0	11.0
			Charring	21.0	22.0	47.0
			Melted through	36.0	37.0	47.0

Critical Thermal Energies of Curtain Materials

Test Code	WADC Mat'l Designation	Material	Description of Effect	Critical Energies (cal/cm^2) At H= 85 cal/cm^2/sec	At H= 42.5 cal/cm^2/sec	At H= 20 cal/cm^2/sec
B	I	Asbeston, MIL-C-8240, Type I (Soiled)	Charring	6.9		
			Burned through, destroyed	23.0		
B	II	Silicone Rubber on Glass Cloth No. 126 (Chemical Rubber Co. Style 7007)(Soiled)	Rubber coating destroyed	54.0		
B	III	Vinyl Coated Cotton Aluminized, MIL-C-7642, Type I(Soiled)	Charring	27.0		
			Burned through, destroyed	39.0		
B	IV	Bleached Cotton Duck, Preshrunk, CCC-D-771, Type III, 14.7 oz., Pyroset DO Treatment (Soiled)	Sporadic Charring	1.4		
			Regular Charring	6.8		
			Charred through destroyed	28.0		
C	I	Asbeston, MIL-C-8240, Type I (Soiled and Cleaned)	Initial Effect	1.4		
			Charring	12.0		
			Burned through, destroyed	32.0		
C	II	Silicone Rubber on Glass Cloth No. 126 (Chemical Rubber Co. Style 7007)(Soiled and Cleaned)	Initial Effect	14.0		
			Rubber Coating, destroyed	77.0		
C	III	Vinyl Coated Cotton, Aluminized, MIL-C-7642, Type I, (Soiled and Cleaned)	Initial Effect	3.0		
			Charring	21.0		
			Burned through, destroyed	42.0		

Critical Thermal Energies of Curtain Materials

Test Code	WADC Mat'l Designation	Material	Description of Effect	Critical Energgies (cal/cm²)		
				At H= 85 cal/cm²/sec	At H= 42.5 cal/cm²/sec	At H= 20 cal/cm²/sec
[illegible]	IV	Bleached Cotton Duck, Preshrunk, CCC-D-771, Type III, 14.7 oz., Pyroset DO Treatment (Soiled and Cleaned)	Sporadic Charring	1.5		
			Regular Charring	6.8		
			Charred through, destroyed	24.0		

Test Code	WADC Mat'l Designation	Material	Description of Effect	Pre-Exposure (cal/cm²)	C.E. cal/cm²
D	I	Asbestos, MIL-C-8240, Type I	Initial Effect	8.8	8.8
			Charring	10.0	18.0
D	II	Silicone Rubber on Glass Cloth No. 126 (Chemical Rubber Co. Style 7007)	Initial Effect	9.0	18.0
D	III	Vinyl coated cotton, aluminized, MIL-C-7642, Type I	Initial Effect	1.9	3.8
D	IV	Bleached Cotton Duck, Preshrunk, CCC-D-771, Type III, 14.7 oz. Pyroset DO Treatment	Sporadic Charring	7.0 - 7.8	7.5
			Regular Charring	9.0 - 10.0	19.0

Critical Thermal Energies of Curtain Materials

Test Code	WADC Mat'l Desig-nation	Material	% Bleach	Description of Effect	Critical Energies (cal/cm^2) At H = 85 cal/cm^2/sec	At H = 42.5 cal/cm^2/sec	At H = 20 cal/cm^2/sec
E	V	Cotton Duck, Preshrunk, CCC-D-771, Type III, 14.7 oz.	0	Charring	11.0	42.0	48.0
				Burned through, destroyed	45.0	66.0	75.0
			25	Charring	34.0	62.0	66.0
				Burned through, destroyed	61.0	74.0	110.0
			50	Charring	39.0	62.0	69.0
				Burned through, destroyed	58.0	74.0	119.0
			75	Charring	27.0	55.0	63.0
				Burned through, destroyed	47.0	75.0	82.0
			100	Charring	31.0	64.0	72.0
				Burned through, destroyed	58.0	81.0	118.0
			125	Charring	31.0	55.0	58.0
				Burned through, destroyed	55.0	74.0	79.0

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